Annex C

Methodology for Estimating Emissions of CH_4, N_2O, and Criteria Pollutants from Mobile Sources

Estimates of CH_4 and N_2O Emissions

Greenhouse gas emissions from mobile sources are reported by transport mode (e.g., road, rail, air, and water), vehicle type, and fuel type. EPA does not systematically track emissions of CH_4 and N_2O as in EPA (1998a); therefore, estimates of these gases were developed using a methodology similar to that outlined in the *Revised 1996 IPCC Guidelines* (IPCC/UNEP/OECD/IEA 1997).

Step 1: Determine Vehicle Miles Traveled or Fuel Consumption by Vehicle Type, Fuel Type, and Model Year

Activity data were obtained from a number of U.S. government agency publications. Depending on the category, these basic activity data included such information as fuel consumption, fuel deliveries, and vehicle miles traveled (VMT). The activity data for highway vehicles included estimates of VMT by vehicle type and model year from EPA (1998a) and the MOBILE5a emissions model (EPA 1997).

National VMT data for gasoline and diesel highway vehicles are presented in Table C-1 and Table C-2, respectively. Total VMT for each highway category (i.e., gasoline passenger cars, light-duty gasoline trucks, heavy-duty gasoline vehicles, diesel passenger cars, light-duty diesel trucks, heavy-duty diesel vehicles, and motorcycles) were distributed across 25 model years based on the temporally fixed age distribution of VMT by the U.S. vehicle fleet in 1990 (see Table C-3) as specified in MOBILE5a. Activity data for gasoline passenger cars and light-duty trucks in California were developed separately due to the different emission control technologies deployed in that state relative to the rest of the country. Unlike the rest of the United States, beginning in model year 1994, a fraction of the computed California VMT for gasoline passenger cars and light-duty trucks was attributed to low emission vehicles (LEVs). LEVs have not yet been widely deployed in other states. Based upon U.S. Department of Transportation statistics for 1994, it was assumed that 8.7 percent of national VMT occurred in California.

Activity data for non-highway vehicles were based on annual fuel consumption statistics by transportation mode and fuel type. Consumption data for distillate and residual fuel oil by ships and boats (i.e., vessel bunkering), construction equipment, farm equipment, and locomotives were obtained from EIA (1998). In the case of ships and boats, the EIA (1998) vessel bunkering data was reduced by the amount of fuel used for international bunkers.[5] Data on the consumption of jet fuel in aircraft were obtained directly from EIA, as described under CO_2 from Fossil Fuel Combustion, and were reduced by the amount allocated to international bunker fuels using data from DOT/BTS (1998). Data on aviation gasoline consumed in aircraft were also taken directly from EIA as above. Data on the consumption of motor gasoline by ships and boats, construction equipment, farm equipment, and locomotives data were drawn from FHWA (1997). For these vehicles, 1996 fuel consumption data were used as a proxy because 1997 data were unavailable. The activity data used for non-highway vehicles are included in Table C-4.

Step 2: Allocate VMT Data to Control Technology Type for Highway Vehicles

For highway sources, VMT by vehicle type for each model year were distributed across various control technologies as shown in Table C-5, Table C-6, Table C-7, Table C-8, and Table C-9. Again, California gasoline-fueled passenger cars and light-duty trucks were treated separately due to that state's distinct mobile source emission standards—including the introduction of Low Emission Vehicles (LEVs) in 1994—compared with the rest of the United States. The categories "Tier 0" and "Tier 1" have been substituted for the early three-way catalyst and advanced three-way catalyst categories, respectively, as defined in the *Revised 1996 IPCC Guidelines*. Tier 0, Tier 1, and LEV

[5] See International Bunker Fuels.

are actually U.S. emission regulations, rather than control technologies; however, each does correspond to particular combinations of control technologies and engine design. Tier 1 and its predecessor Tier 0 both apply to vehicles equipped with three-way catalysts. The introduction of "early three-way catalysts," and "advance three-way catalysts" as described in the *Revised 1996 IPCC Guidelines*, roughly correspond to the introduction of Tier 0 and Tier 1 regulations (EPA 1998).

Step 3: Determine the Amount of CH_4 and N_2O Emitted by Vehicle, Fuel, and Control Technology Type

Emissions of CH_4 from mobile source combustion and N_2O from non-highway vehicles were calculated by multiplying emission factors in IPCC/UNEP/OECD/IEA (1997) by activity data for each vehicle type as described in Step 1 (see Table C-10 and Table C-11). The CH_4 emission factors for highway sources were derived from EPA's MOBILE5a mobile source emissions model (EPA 1997). The MOBILE5a model uses information on ambient temperature, diurnal temperature range, altitude, vehicle speeds, national vehicle registration distributions, gasoline volatility, emission control technologies, fuel composition, and the presence or absence of vehicle inspection/maintenance programs in order to produce these factors.

Emissions of N_2O—in contrast to CH_4, CO, NO_x, and NMVOCs—have not been extensively studied and are currently not well characterized. The limited number of studies that have been performed on highway vehicle emissions of N_2O have shown that emissions are generally greater from vehicles with catalytic converter systems than those without such controls, and greater from aged than from new catalysts. These systems control tailpipe emissions of NO_x (i.e., NO and NO_2) by catalytically reducing NO_x to N_2. Suboptimal catalyst performance, caused by as yet poorly understood factors, results in incomplete reduction and the conversion of some NO_x to N_2O rather than to N_2. Fortunately, newer vehicles with catalyst and engine designs meeting the more recent Tier 1 and LEV standards have shown reduced emission rates of both NO_x and N_2O.

In order to better characterize the process by which N_2O is formed by catalytic controls and to develop a more accurate national emission estimate, the EPA's Office of Mobile Sources—at its National Vehicle and Fuel Emissions Laboratory (NVFEL)—recently conducted a series of tests in order to measure emission rates of N_2O from used Tier 1 and LEV gasoline-fueled passenger cars and light-duty trucks equipped with catalytic converters. These tests and a review of the literature were used to develop the emission factors for nitrous oxide used in this inventory (EPA 1998b). The following references were used in developing the N_2O emission factors for gasoline-fueled highway passenger cars presented in Table C-10:

LEVs. Tests performed at NVFEL (EPA 1998b)[6]

Tier 1. Tests performed at NVFEL (EPA 1998b)

Tier 0. Smith and Carey (1982), Barton and Simpson (1994), and one car tested at NVFEL (EPA 1998b)

Oxidation Catalyst. Smith and Carey (1982), Urban and Garbe (1979)

Non-Catalyst. Prigent and de Soete (1989), Dasch (1992), and Urban and Garbe (1979)

Nitrous oxide emission factors for other types of gasoline-fueled vehicles—light-duty trucks, heavy-duty vehicles, and motorcycles—were estimated by adjusting the factors for gasoline passenger cars, as described above, by their relative fuel economies. This adjustment was performed using the carbon dioxide emission rates in the *Revised 1996 IPCC Guidelines* (IPCC/UNEP/OECD/IEA 1997) as a proxy for fuel economy (see Table C-10). Data from the literature and tests performed at NVFEL support the conclusion that light-duty trucks have higher emission rates than passenger cars. However, the use of fuel-consumption ratios to determine emission factors is considered a temporary measure only, to be replaced as soon as real data are available.

[6] It was assumed that LEVs would be operated using low-sulfur fuel (i.e., Indolene at 24 ppm sulfur). All other NVFEL tests were performed using a standard commercial fuel (CAAB at 285 ppm sulfur). Emission tests by NVFEL have consistently exhibited higher N_2O emission rates from higher sulfur fuels on Tier 1 and LEV vehicles.

The resulting N_2O emission factors employed for gasoline highway vehicles are lower than the U.S. default values presented in the *Revised 1996 IPCC Guidelines*, but are higher than the European default values, both of which were published before the more recent tests and literature review conducted by the NVFEL. The U.S. defaults in the *Guidelines* were based on three studies that tested a total of five cars using European rather than U.S. test procedures. Nitrous oxide emission factors for diesel highway vehicles were taken from the European default values found in the *Revised 1996 IPCC Guidelines* (IPCC/UNEP/OECD/IEA 1997). There is little data addressing N_2O emissions from U.S. diesel-fueled vehicles, and in general, European countries have had more experience with diesel-fueled vehicles. U.S. default values in the *Revised 1996 IPCC Guidelines* were used for non-highway vehicles.

Compared to regulated tailpipe emissions, there is relatively little data available to estimate emission factors for nitrous oxide. Nitrous oxide is not a criteria pollutant, and measurements of it in automobile exhaust have not been routinely collected. Further testing is needed to reduce the uncertainty in nitrous oxide emission factors for all classes of vehicles, using realistic driving regimes, environmental conditions, and fuels.

Estimates of NO_x, CO, and NMVOC Emissions

The emission estimates of NO_x, CO, and NMVOCs for mobile sources were taken directly from the EPA's *Draft National Air Pollutant Emissions Trends, 1900 - 1997* (EPA 1998a). This EPA report provides emission estimates for these gases by sector and fuel type using a "top down" estimating procedure whereby emissions were calculated using basic activity data, such as amount of fuel delivered or miles traveled, as indicators of emissions. Table C-12 through Table C-14 provide complete emissions estimates for 1990 through 1997.

Table C-1: Vehicle Miles Traveled for Gasoline Highway Vehicles (10^9 Miles)

Year	Passenger Cars[a]	Light-Duty Trucks[a]	Heavy-Duty Vehicles	Motorcycles	Passenger Cars (CA)[b]	Light-Duty Trucks (CA)[b]
1990	1,492.61	462.31	43.32	9.57	129.86	40.22
1991	1,512.72	468.92	43.60	9.20	131.61	40.80
1992	1,574.56	472.90	43.39	9.55	136.99	41.14
1993	1,602.28	493.20	45.96	9.89	139.40	42.91
1994	1,562.48	581.83	49.67	10.25	135.94	50.62
1995	1,605.74	597.92	51.04	10.52	139.70	52.02
1996	1,443.59	806.21	51.66	9.87	125.59	70.14
1997	1,475.85	824.31	52.89	10.10	128.40	71.71

[a] Excludes California

[b] California VMT for passenger cars and light-duty trucks was treated separately and estimated as 8.7 percent of national total.

Source: VMT data are the same as those used in EPA (1998a).

Table C-2: Vehicle Miles Traveled for Diesel Highway Vehicles (10^9 Miles)

Year	Passenger Cars	Light-Duty Trucks	Heavy-Duty Vehicles
1990	20.6	3.8	112.2
1991	20.9	3.8	112.9
1992	21.7	3.9	115.0
1993	22.1	4.1	119.6
1994	21.5	4.8	127.0
1995	22.1	4.9	130.5
1996	19.9	6.7	137.1
1997	20.4	6.8	140.5

Source: VMT data are the same as those used in EPA (1998a).

Table C-3: VMT Profile by Vehicle Age (years) and Vehicle/Fuel Type for Highway Vehicles (percent of VMT)

Vehicle Age	LDGV	LDGT	HDGV	LDDV	LDDT	HDDV	MC
1	4.9%	6.3%	2.3%	4.9%	6.3%	3.4%	14.4%
2	7.9%	8.4%	4.7%	7.9%	8.4%	6.7%	16.8%
3	8.3%	8.4%	4.7%	8.3%	8.4%	6.7%	13.5%
4	8.2%	8.4%	4.7%	8.2%	8.4%	6.7%	10.9%
5	8.4%	8.4%	4.7%	8.4%	8.4%	6.7%	8.8%
6	8.1%	6.9%	3.8%	8.1%	6.9%	7.3%	7.0%
7	7.7%	5.9%	3.3%	7.7%	5.9%	6.1%	5.6%
8	5.6%	4.4%	2.1%	5.6%	4.4%	4.0%	4.5%
9	5.0%	3.6%	2.6%	5.0%	3.6%	4.1%	3.6%
10	5.1%	3.1%	2.9%	5.1%	3.1%	5.1%	2.9%
11	5.0%	3.0%	3.4%	5.0%	3.0%	5.3%	2.3%
12	5.4%	5.3%	6.4%	5.4%	5.3%	6.6%	9.7%
13	4.7%	4.7%	5.4%	4.7%	4.7%	5.5%	0.0%
14	3.7%	4.6%	5.8%	3.7%	4.6%	5.7%	0.0%
15	2.4%	3.6%	5.1%	2.4%	3.6%	4.5%	0.0%
16	1.9%	2.8%	3.8%	1.9%	2.8%	1.9%	0.0%
17	1.4%	1.7%	4.3%	1.4%	1.7%	2.3%	0.0%
18	1.5%	2.2%	4.1%	1.5%	2.2%	2.8%	0.0%
19	1.1%	1.7%	3.5%	1.1%	1.7%	2.4%	0.0%
20	0.8%	1.4%	2.9%	0.8%	1.4%	1.6%	0.0%
21	0.6%	0.9%	2.1%	0.6%	0.9%	1.1%	0.0%
22	0.5%	0.8%	2.2%	0.5%	0.8%	0.9%	0.0%
23	0.4%	0.8%	2.2%	0.4%	0.8%	0.7%	0.0%
24	0.3%	0.5%	1.4%	0.3%	0.5%	0.5%	0.0%
25	1.0%	2.5%	11.7%	1.0%	2.5%	1.6%	0.0%

LDGV (gasoline passenger cars, also referred to as light-duty gas vehicles)
LDGT (light-duty gas trucks)
HDGV (heavy-duty gas vehicles)
LDDV (diesel passenger cars, also referred to as light-duty diesel vehicles)
LDDT (light-duty diesel trucks)
HDDV (heavy-duty diesel vehicles)
MC (motorcycles)

Table C-4: Fuel Consumption for Non-Highway Vehicles by Fuel Type (U.S. gallons)

Vehicle Type/Year	Residual	Diesel	Jet Fuel	Other
Aircraft[a]				
1990	-	-	19,138,571,644	374,401,818
1991	-	-	18,362,671,260	346,945,685
1992	-	-	17,978,360,318	341,953,660
1993	-	-	18,099,464,134	319,448,684
1994	-	-	18,885,264,653	317,309,701
1995	-	-	18,397,377,217	329,315,519
1996	-	-	19,296,093,738	310,795,109
1997	-	-	19,123,384,372	330,280,644
Ships and Boats[b]				
1990	1,666,165,227	1,943,259,570	-	1,300,400,000
1991	1,486,167,178	1,806,653,451	-	1,709,700,000
1992	2,347,064,583	1,820,275,621	-	1,316,170,000
1993	2,758,924,466	1,661,285,902	-	873,687,000
1994	2,499,868,472	1,746,597,258	-	896,700,000
1995	2,994,692,916	1,636,189,216	-	1,060,394,000
1996	2,280,373,162	1,952,357,254	-	993,671,000
1997	1,005,997,126	1,917,777,070	-	993,671,000

Vehicle Type/Year	Residual	Diesel	Jet Fuel	Other
Construction Equipment[c]				
1990	-	2,508,300,000	-	1,523,600,000
1991	-	2,447,400,000	-	1,384,900,000
1992	-	2,287,642,000	-	1,492,200,000
1993	-	2,323,183,000	-	1,270,386,667
1994	-	2,437,142,000	-	1,312,161,667
1995	-	2,273,162,000	-	1,351,642,667
1996	-	2,386,973,000	-	1,365,550,667
1997	-	2,385,236,000	-	1,365,550,667
Farm Equipment[d]				
1990	-	3,164,200,000	-	812,800,000
1991	-	3,144,200,000	-	776,200,000
1992	-	3,274,811,000	-	805,500,000
1993	-	3,077,122,000	-	845,320,000
1994	-	3,062,436,000	-	911,996,000
1995	-	3,093,224,000	-	926,732,000
1996	-	3,225,029,000	-	918,085,000
1997		3,206,359,000		918,085,000
Locomotives				
1990	25,422	3,210,111,000	-	-
1991	6,845	3,026,292,000	-	-
1992	8,343	3,217,231,000	-	-
1993	4,065	2,906,998,000	-	-
1994	5,956	3,063,441,000	-	-
1995	6,498	3,191,023,000	-	-
1996	9,309	3,266,861,000	-	-
1997	3,431	3,067,400,000	-	-

- Not applicable

[a] Other fuel aviation gasoline.

[b] Other fuel motor gasoline.

[c] Construction Equipment includes snowmobiles. Other fuel is motor gasoline.

[d] Other fuel is motor gasoline.

Table C-5: Control Technology Assignments for Gasoline Passenger Cars (percentage of VMT)*

Model Years	Non-catalyst	Oxidation	Tier 0	Tier 1
1973-1974	100%			
1975	20%	80%		
1976-1977	15%	85%		
1978-1979	10%	90%		
1980	5%	88%	7%	
1981		15%	85%	
1982		14%	86%	
1983		12%	88%	
1984-1993			100%	
1994			60%	40%
1995			20%	80%
1996				100%
1997				100%

* Excluding California VMT

Table C-6: Control Technology Assignments for Gasoline Light-Duty Trucks (percentage of VMT)*

Model Years	Non-catalyst	Oxidation	Tier 0	Tier 1
1973-1974	100%			
1975	30%	70%		
1976	20%	80%		
1977-1978	25%	75%		
1979-1980	20%	80%		
1981		95%	5%	
1982		90%	10%	
1983		80%	20%	
1984		70%	30%	
1985		60%	40%	
1986		50%	50%	
1987-1993		5%	95%	
1994			60%	40%
1995			20%	80%
1996				100%
1997				100%

* Excluding California VMT

Table C-7: Control Technology Assignments for California Gasoline Passenger Cars and Light-Duty Trucks (percentage of VMT)

Model Years	Non-catalyst	Oxidation	Tier 0	Tier 1	LEV
1973-1974	100%				
1975-1979		100%			
1980-1981		15%	85%		
1982		14%	86%		
1983		12%	88%		
1984-1991			100%		
1992			60%	40%	
1993			20%	80%	
1994				90%	10%
1995				85%	15%
1996				80%	20%
1997				75%	25%

Table C-8: Control Technology Assignments for Gasoline Heavy-Duty Vehicles (percentage of VMT)

Model Years	Uncontrolled	Non-catalyst	Oxidation	Tier 0
#1981	100%			
1982-1984	95%		5%	
1985-1986		95%	5%	
1987		70%	15%	15%
1988-1989		60%	25%	15%
1990-1997		45%	30%	25%

Table C-9: Control Technology Assignments for Diesel Highway VMT

Vehicle Type/Control Technology	Model Years
Diesel Passenger Cars and Light-Duty Trucks	
Uncontrolled	1966-1982
Moderate control	1983-1995
Advanced control	1996-1997
Heavy-Duty Diesel Vehicles	
Uncontrolled	1966-1972
Moderate control	1983-1995
Advanced control	1996-1997
Motorcycles	
Uncontrolled	1966-1995
Non-catalyst controls	1996-1997

Table C-10: Emission Factors (g/km) for CH_4 and N_2O and "Fuel Economy" (g CO_2/km)[c] for Highway Mobile Sources

Vehicle Type/Control Technology	N_2O	CH_4	g CO_2/km
Gasoline Passenger Cars			
Low Emission Vehicles[a]	0.0176	0.025	280
Tier 1	0.0288	0.030	285
Tier 0	0.0507	0.040	298
Oxidation Catalyst	0.0322	0.070	383
Non-Catalyst	0.0103	0.120	531
Uncontrolled	0.0103	0.135	506
Gasoline Light-Duty Trucks			
Low Emission Vehicles[a]	0.0249	0.030	396
Tier 1	0.0400	0.035	396
Tier 0	0.0846	0.070	498
Oxidation Catalyst	0.0418	0.090	498
Non-Catalyst	0.0117	0.140	601
Uncontrolled	0.0118	0.135	579
Gasoline Heavy-Duty Vehicles			
Tier 0	0.1729	0.075	1,017
Oxidation Catalyst[b]	0.0870	0.090	1,036
Non-Catalyst Control	0.0256	0.125	1,320
Uncontrolled	0.0269	0.270	1,320
Diesel Passenger Cars			
Advanced	0.0100	0.01	237
Moderate	0.0100	0.01	248
Uncontrolled	0.0100	0.01	319
Diesel Light Trucks			
Advanced	0.0200	0.01	330
Moderate	0.0200	0.01	331
Uncontrolled	0.0200	0.01	415
Diesel Heavy-Duty Vehicles			
Advanced	0.0300	0.04	987
Moderate	0.0300	0.05	1,011
Uncontrolled	0.0300	0.06	1,097
Motorcycles			
Non-Catalyst Control	0.0042	0.13	219
Uncontrolled	0.0054	0.26	266

[a] Applied to California VMT only.

[b] Methane emission factor assumed based on light-duty trucks oxidation catalyst value.

[c] The carbon emission factor (g CO_2/km) was used as a proxy for fuel economy because of the greater number of significant figures compared to the km/L values presented in (IPCC/UNEP/OECD/IEA 1997).

NA (Not Available)

Table C-11: Emission Factors for CH_4 and N_2O Emissions from Non-Highway Mobile Sources (g/kg fuel)

Vehicle Type/Fuel Type	N_2O	CH_4
Ships and Boats		
Residual	0.08	0.23
Distillate	0.08	0.23
Gasoline	0.08	0.23
Locomotives		
Residual	0.08	0.25
Diesel	0.08	0.25
Coal	0.08	0.25
Farm Equipment		
Gas/Tractor	0.08	0.45
Other Gas	0.08	0.45
Diesel/Tractor	0.08	0.45
Other Diesel	0.08	0.45
Construction		
Gas Construction	0.08	0.18
Diesel Construction	0.08	0.18
Other Non-Highway		
Gas Snowmobile	0.08	0.18
Gas Small Utility	0.08	0.18
Gas HD Utility	0.08	0.18
Diesel HD Utility	0.08	0.18
Aircraft		
Jet Fuel	0.1	0.087
Aviation Gasoline	0.04	2.64

Table C-12: NO_x Emissions from Mobile Sources, 1990-1997 (Gg)

Fuel Type/Vehicle Type	1990	1991	1992	1993	1994	1995	1996	1997
Gasoline Highway	**4,356**	**4,654**	**4,788**	**4,913**	**5,063**	**4,804**	**4,770**	**4,629**
Passenger Cars	2,910	3,133	3,268	3,327	3,230	3,112	2,691	2,597
Light-Duty Trucks	1,140	1,215	1,230	1,289	1,503	1,378	1,769	1,725
Heavy-Duty Vehicles	296	296	280	286	318	301	298	296
Motorcycles	11	10	11	11	11	12	11	11
Diesel Highway	**2,031**	**2,035**	**1,962**	**1,900**	**1,897**	**1,839**	**1,803**	**1,753**
Passenger Cars	35	34	35	36	35	35	31	31
Light-Duty Trucks	6	7	7	7	9	9	11	11
Heavy-Duty Vehicles	1,989	1,995	1,920	1,857	1,854	1,795	1,760	1,711
Non-Highway	**3,844**	**3,869**	**3,910**	**3,936**	**3,989**	**4,089**	**4,063**	**4,137**
Ships and Boats	253	265	259	250	254	264	265	273
Locomotives	843	842	858	857	859	898	836	861
Farm Equipment	894	905	918	931	943	955	965	962
Construction Equipment	1,015	1,026	1,039	1,054	1,071	1,094	1,110	1,120
Aircraft[a]	143	141	142	142	146	150	151	161
Other[b]	697	690	695	703	716	729	736	759
Total	**10,231**	**10,558**	**10,659**	**10,749**	**10,949**	**10,732**	**10,636**	**10,519**

[a] Aircraft estimates include only emissions related to LTO cycles, and therefore do not include cruise altitude emissions.

[b] "Other" includes gasoline powered recreational, industrial, lawn and garden, light commercial, logging, airport service, other equipment; and diesel powered recreational, industrial, lawn and garden, light construction, airport service.

Note: Totals may not sum due to independent rounding.

Table C-13: CO Emissions from Mobile Sources, 1990-1997 (Gg)

Fuel Type/Vehicle Type	1990	1991	1992	1993	1994	1995	1996	1997
Gasoline Highway	**51,332**	**55,104**	**53,077**	**53,375**	**54,778**	**47,767**	**46,965**	**44,225**
Passenger Cars	33,746	36,369	35,554	35,357	33,850	30,391	25,894	24,356
Light-Duty Trucks	12,534	13,621	13,215	13,786	15,739	13,453	17,483	16,659
Heavy-Duty Vehicles	4,863	4,953	4,145	4,061	5,013	3,741	3,416	3,039
Motorcycles	190	161	163	172	177	182	171	171
Diesel Highway	**1,147**	**1,210**	**1,227**	**1,240**	**1,316**	**1,318**	**1,354**	**1,368**
Passenger Cars	28	27	28	30	29	30	27	27
Light-Duty Trucks	5	5	6	6	7	7	10	10
Heavy-Duty Vehicles	1,115	1,177	1,193	1,205	1,280	1,281	1,318	1,332
Non-Highway	**13,949**	**13,942**	**14,199**	**14,359**	**14,560**	**14,761**	**14,886**	**15,201**
Ships and Boats	1,619	1,644	1,659	1,672	1,684	1,678	1,689	1,704
Locomotives	110	109	113	108	104	103	102	105
Farm Equipment	355	317	344	354	324	298	302	298
Construction Equipment	936	932	957	991	1,042	1,072	1,079	1,080
Aircraft[a]	820	806	818	821	830	855	861	918
Other[b]	10,110	10,134	10,308	10,413	10,577	10,755	10,854	11,096
Total	**66,429**	**70,256**	**68,503**	**68,974**	**70,655**	**63,846**	**63,205**	**60,794**

[a] Aircraft estimates include only emissions related to LTO cycles, and therefore do not include cruise altitude emissions.
[b] "Other" includes gasoline powered recreational, industrial, lawn and garden, light commercial, logging, airport service, other equipment; and diesel powered recreational, industrial, lawn and garden, light construction, airport service.
Note: Totals may not sum due to independent rounding.

Table C-14: NMVOCs Emissions from Mobile Sources, 1990-1997 (Gg)

Fuel Type/Vehicle Type	1990	1991	1992	1993	1994	1995	1996	1997
Gasoline Highway	**5,444**	**5,607**	**5,220**	**5,248**	**5,507**	**4,883**	**4,743**	**4,528**
Passenger Cars	3,524	3,658	3,447	3,427	3,367	3,071	2,576	2,467
Light-Duty Trucks	1,471	1,531	1,440	1,494	1,731	1,478	1,869	1,785
Heavy-Duty Vehicles	392	384	303	296	375	297	266	243
Motorcycles	56	33	30	31	33	37	33	33
Diesel Highway	**283**	**290**	**288**	**288**	**300**	**290**	**238**	**217**
Passenger Cars	11	11	12	12	12	12	11	11
Light-Duty Trucks	2	3	3	3	4	4	5	5
Heavy-Duty Vehicles	269	276	274	273	284	274	223	201
Non-Highway	**2,225**	**2,237**	**2,266**	**2,282**	**2,303**	**2,182**	**2,175**	**2,205**
Ships and Boats	563	571	576	580	584	439	464	468
Locomotives	48	47	49	47	45	45	44	45
Farm Equipment	135	131	131	130	126	123	121	116
Construction Equipment	197	198	202	207	213	219	219	219
Aircraft[a]	163	161	162	160	159	161	161	170
Other[b]	1,120	1,129	1,146	1,160	1,175	1,196	1,167	1,186
Total	**7,952**	**8,133**	**7,774**	**7,819**	**8,110**	**7,354**	**7,156**	**6,949**

[a] Aircraft estimates include only emissions related to LTO cycles, and therefore do not include cruise altitude emissions.
[b] "Other" includes gasoline powered recreational, industrial, lawn and garden, light commercial, logging, airport service, other equipment; and diesel powered recreational, industrial, lawn and garden, light construction, airport service.
Note: Totals may not sum due to independent rounding.